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- Toshiba Overview
- Toshiba Experiences of Accelerator
- Key Feature of Toshiba Accelerator Technology
- Conclusion
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Toshiba New Business Structure

Before

- Toshiba Corporation
  - Corporate
    - Energy Systems & Solutions Company
    - Nuclear Energy Systems & Solutions Division
    - Infrastructure Systems & Solutions Company
    - Storage & Electronic Devices Solutions Company
    - Industrial ICT Solutions Company

After

- Toshiba Corporation
  - Toshiba Energy Systems & Solutions Corporation
    - Toshiba Infrastructure Systems & Solutions Corporation
    - Toshiba Electronic Devices & Storage Corporation
    - Toshiba Digital Solutions Corporation
Toshiba New Business Structure
## Company Outline

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Toshiba Energy Systems &amp; Solutions Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headquaters</td>
<td>Address: 72-34, Horikawa-cho, Saiwai-ku, Kawasaki-shi, Kanagawa</td>
</tr>
<tr>
<td>Date of Succession</td>
<td>October 1, 2017 (Split off from Toshiba Corporation)</td>
</tr>
<tr>
<td>President and CEO</td>
<td>Yoshihiro Aburatani</td>
</tr>
<tr>
<td>Common Stock</td>
<td>¥10 billion</td>
</tr>
<tr>
<td>Business Outline</td>
<td>Development, manufacture and sales of energy business products, systems and services</td>
</tr>
<tr>
<td>Net Sales</td>
<td>¥974.9 billion (Consolidated net sales of Toshiba group, energy business, FY2016)</td>
</tr>
<tr>
<td>Number of Employees</td>
<td>Approx. 7,200 (as of 1st Oct, 2017)</td>
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TOSHIBA Experiences of Accelerator
Accelerator System
Accelerator System

Super Photon ring-8 GeV (SPring-8)

8GeV Booster Synchrotron

1GeV Linac

8GeV Storage Ring

Customer: JAERI/RIKEN
Public use since 1997

- 8GeV Booster Synchrotron System
- 1GeV Electron Linac (RF pulser system)
- 8GeV Storage Ring (RF system)
Synchrotron System

SPring-8 Booster Synchrotron

Experience

- [Image of synchrotron system]

- [Image of synchrotron system]

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Storage Ring RF System

SPring-8 RF System for Storage Ring

- **Cavity:**
  - Single Cell 8 stations
  - Input Power 150kW

- **Klystron:**
  - E3732
  - Frequency 508.58 MHz
  - Max. Output 1 MW(CW)
Storage Ring RF System

Australian Synchrotron RF System

Customer : Major Project Victoria
Operation since 2006

Main Parameter
• Frequency  499.654MHz
• Max. Voltage  750kV/cavity
• HOM Damped Cavity
• Klystron E3774U (Efficiency >60%)
**Injector Linac**
- Electron energy: 50MeV
- RF frequency: 2856MHz

**Booster Synchrotron**
- Electron energy: 1.2GeV
- Circumference: 49.2m
- Repetition rate: 1Hz

**Storage Ring**
- Electron energy: 1.2GeV
- Circumference: 72m
- Current: 300mA
- Emittance: 50nmrad

*Operation since 2012*

(C) Aichi Synchrotron Radiation Center
Heavy Ion Synchrotron

Contribution to Building HIMAC Synchrotron

Operation since 1994

(C)NIRS

HIMAC: Heavy Ion Medical Accelerator in Chiba
Heavy Ion Cancer Therapy System

Contribution to Building New Treatment Facility

1. New High energy beam transfer line (HEBT)
2. Treatment rooms E & F (Operating in 2011)
   - Patient handling system with robot-arm bed
   - 3D high-speed scanning irradiation system
   - Treatment management for particle therapy
3. Treatment room G (Operating in 2015)
   - Superconducting rotating gantry
Superconducting Magnet System

Superconducting Rotating Gantry for NIRS
Heavy Ion Cancer Therapy System

Kanagawa Cancer Center i-ROCK

- “i-ROCK” is TOSHIBA’s 1st machine to the market based on NIRS technologies.
- The treatment stared since 2015.

Experience

Synchrotron
Injector
Ion Source

Room 1
Room 2
Room 3
Room 4

Accelerator

Treatment Room
Heavy Ion Cancer Therapy System

Yamagata University Hospital

- Fix port Treatment Room (Horizontal)
- Injector
- Synchrotron
- Ion Source
- Gantry Treatment Room
- Superconducting Gantry
- Irradiation port 60% downsize

New Gantry Length ~9m

NIRS Gantry Length ~14m

Superconducting Gantry

Iso-center

Scanning Magnets

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Superconducting Magnet

ATLAS Central Solenoid Magnet for LHC

Main Parameter:
- Coil Inner Radius 1229mm
- Coil Length 5300mm
- Conductor 30mm × 4.3mm NbTi/Cu/Al

Coil Parameter:
- Operation Current 7600A
- Stored Energy 39MJ
- Central Magnetic Field 2T

CERN/KEK LHC operation since 2003
Superconducting Magnet

Superconducting Quadrupole Magnet for LHC (MQX-A)

Main Parameter:
- Magnet Length: 6.3m
- Coil Inner Radius: 35mm
- Magnet Outer Radius: 245mm
- Weight: 8.3ton

Coil Parameter:
- Nominal Current: 8057A
- Stored Energy: 2.8MJ
- Peak Field (Nominal): 9.6T
- Cooling: 1.8K LHe
Superconducting Magnet

Superconducting Triplet Q Magnet for RIKEN BigRIPS

- **Main Parameter**: Superferric
  - Type: Superferric
  - Eff. Length: 0.5m/0.8m/0.5m
  - Warm Bore Radius: 0.14m

- **Coil Parameter**: 135A
  - Nominal Current: 135A
  - Peak Field(Nominal): 4T
  - Winding: Race Track
  - Cooling: Liquid Helium

(C)RIKEN
Superconducting Magnet System

Liquid-helium Cryogenic Plant for RIKEN BigRIPS

Buffer Tank
100m³ + 2.10m³ + 1
(Φ3m × 15m height)

He Compressor
(315kW)

Cold Box
(390W@4.5K)

4.5K LHe Dewar (2000L)

BigRIPS Beam Line
TOSHIBA’S Accelerator Technologies

Key Features

- Accelerator Physics Design & Analysis
- System Integration Engineering
- Superconducting Magnet Manufacturing Techniques
- Special Manufacturing Techniques
- Installation/Testing Supervising
Accelerator Physics Design & Analysis

- **Lattice Design**
  - Toshiba’s design capability includes not only manufacturing/testing but basic accelerator planning design such as lattice design and beam physics.

- **RF/ Mechanical/ Thermal Analysis**
  - Toshiba’s capability includes special analysis technology:
    - 2D/3D Electromagnetic Analysis, Thermal and Deformation Analysis
System Integration Engineering

- Accelerator Physics Design & Analysis
- System Design
  - Equipment List & Specification
  - System Layout
  - Single Line Diagram
  - Earthing Diagram
  - P&ID
- Equipment Design
  - Magnet & Power Supply
  - Monitor System
  - Vacuum System
  - RF System
  - Control System
- Installation & Testing
  - Installation & Assembling
  - Precise Alignment
  - Equipment Test
  - System Test
  - Beam commissioning

Optimization
Various Superconducting Magnet manufacturing techniques

- Precise winding: Long length & Precise coil.
- Surface winding: Free shape winding
Precise Machining and Bonding for RF Cavity

- Realize maximization of Q value, minimization of deformation and no water leakage.

Precise Alignment

- Rich experiences of precise alignment for accelerator facilities using Laser Tracker and other optical measuring instruments.
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For Realizing EUV-EFL

Accelerator Technology + Superconducting Technology Is the Key to the Future
For Realizing EUV-EFL - R&D Activities of Toshiba -

- Superconducting Cavity Prototype
  ILC specification has been accomplished:
  \[ E_{\text{acc,max}} = 35 \text{MV/m} \quad \text{and} \quad Q_0 = 8 \times 10^9 \]

- HOM Damper Prototype
  Completed manufacturing Prototype.

- Photo cathode Electron gun
  Completed basic design.

R&D process is steadily heading towards success
Conclusion

- Toshiba provides the most highly advanced, reliable and stable Accelerator Components and System applying Superconducting Technology, based on our successful experiences.

- Toshiba can
  - contribute from planning stage based on our Accelerator and system engineering capability with Superconducting Technology.
  - provide excellent accelerator components based on our vast design and manufacturing experiences.

We believe that we can contribute to the progress of future industry & science